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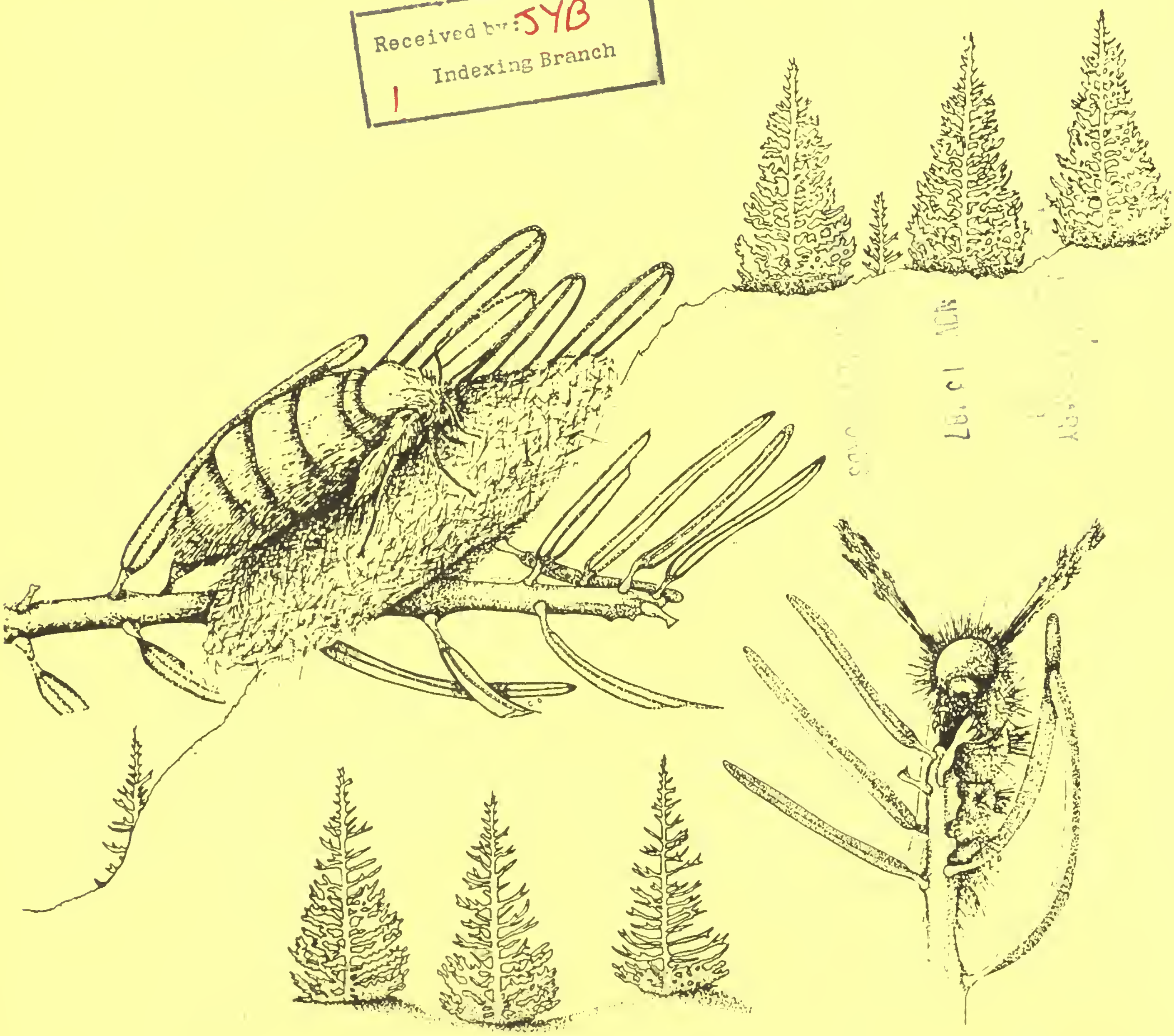
The Use of Degree-day Accumulation for Monitoring Douglas-fir Tussock Moth (Lepidoptera: Lymantriidae) Populations



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The Use of Degree-day Accumulation for Monitoring Douglas-fir Tussock Moth (Lepidoptera:Lymantriidae) Populations

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ABSTRACT

The relationship between accumulation of degree-days and Douglas-fir tussock moth, *Orgyia pseudotsugata* (McDunnough), development provides a means for predicting eclosion and early instar larval development. Accurate predictions of larval development assists land managers in monitoring population development and for optimal timing of suppression projects.

INTRODUCTION

Degree-day accumulation is a practical method of assessing populations of a wide variety of agricultural insects (Bean and Wilson 1964, Cameron et al 1968, Morris and Bennett 1967, Sevacherian et al 1977). This method of predicting insect development and optimal timing of suppression projects is a necessary step in integrated forest pest management (Toscano et al 1979, Sevachevian et al 1977, Wickman 1981). The phenology of the Douglas-fir tussock moth, *Orgyia pseudotsugata* (McDunnough), and its host trees are closely associated (Beckwith 1976, Wickman 1976a, 1976b, 1977, 1978). The relationship between accumulation of degree-days and insect-host phenology can be used to more efficiently predict the timing of sampling and suppression projects. The method described in this paper discusses the use of accumulated degree-days to predict timing of sampling and suppression of Douglas-fir tussock moth populations in New Mexico.

METHODS

Predictions of eclosion and larval instar development were based on accumulated degree-days beginning on May 1. Degree-days are calculated using the following formula:

$$\text{Degree-days} = \frac{h + m}{2} - t \qquad \text{where } \frac{h + m}{2} > t$$

$$= 0 \qquad \text{where } \frac{h + m}{2} \leq t$$

Where h = maximum daily temperature, m = minimum daily temperature, and t = threshold temperature. The threshold temperature for egg hatch for the Douglas-fir tussock moth is 42° F (5.5° C) (Wickman 1976a; 1976b). All plus degree-day values are accumulated. Negative values are treated as zero values and do not enter into the calculation.

Maximum and minimum temperature data were obtained from the Environmental Data and Information Service, National Oceanic and Atmospheric Administration.

The method was designed using data from suppression projects in Santa Fe, New Mexico, during 1974 to 1976. Weather stations in downtown Santa Fe and at the College of Santa Fe were used to collect temperature data. In 1978, the method was evaluated in an operational test near Los Alamos, New Mexico, using weather stations at the Los Alamos Airport. An untreated check area in the vicinity of Medio Dia Canyon was monitored with a portable weather station.

In Santa Fe, egg masses in a cool location were selected and observed for eclosion. In Los Alamos and Medio Dia Canyon, egg masses on warm Mesa tops and cool canyon bottoms were observed. When eclosion occurs on a cool site, eclosion on warmer sites should be nearly complete with larval dispersal occurring on the warmest sites.

RESULTS AND DISCUSSION

Field experiments were conducted from 1974-76 to evaluate various formulations of *Bacillus thuringiensis* against the Douglas-fir tussock moth. In 1974 and 1975, dates of application were set at ca. 2 weeks after initial egg hatch. In 1976, the date of application was based on accumulated degree-days. Accumulated degree-days, date of eclosion and spray date are graphically illustrated in figure 1.

In 1974, excellent control was achieved. Timing of application was optimal--eclosion and larval dispersal was complete and 2nd instar larvae (80%) predominated. Though many factors affect the efficacy of *B.t.*, it is most important that the larvae be dispersed and actively feeding (Harper 1974). Improper timing of application in 1975 accounted for the poor treatment results. Because of unseasonably cool weather, larval dispersal was incomplete and 1st instar larvae predominated at 14 days after initial egg hatch.

Accumulated degree-day data in 1974 and 1975 show that larval dispersal and development were optimal at ca. 500 degree-days in 1974, and less than optimal at ca. 375 degree-days in 1975 (Table 1).

The date of application for 1976 was set at 500 degree-days based on the results of the 1974 and 1975 tests. The actual spray date was June 4. On June 4, 531 degree-days had accumulated. Timing of application was optimal--eclosion and larval dispersal complete and 2nd instar larvae (71%) predominated.

In 1978, the method was tested under an operational forest application using the nucleopolyhedrosis virus. Initial egg hatch was observed in the cooler portions of Los Alamos and Pueblo Canyons, as well as on the warmer mesa tops adjoining the canyons. Initial egg hatch in the cool canyon bottoms (Table 1) occurred on May 22 (215 degree-days) and on the mesa tops on May 15 (120 degree-days). Application was on June 3 and 4 (423 and 443 degree-days). Because the majority of the unit was on warmer sites, an earlier-than-predicted spray date was established. On the mesa tops, timing of application was optimal--eclosion and larval dispersal were complete and 2nd and 3rd instar larvae (52% 2nd and 30% 3rd instar); and, suboptimal in the canyon bottoms (60% 1st instar). In Medio Dia Canyon, the untreated check area, initial eclosion on the warm site occurred on May 15 (165 degree-days) and on the cool site on May 19 (232 degree-days) (Figure 2).

Figure 1. Accumulated degree-days, predicted eclosion date, and optimal spray date, Santa Fe, New Mexico, 1974-1976

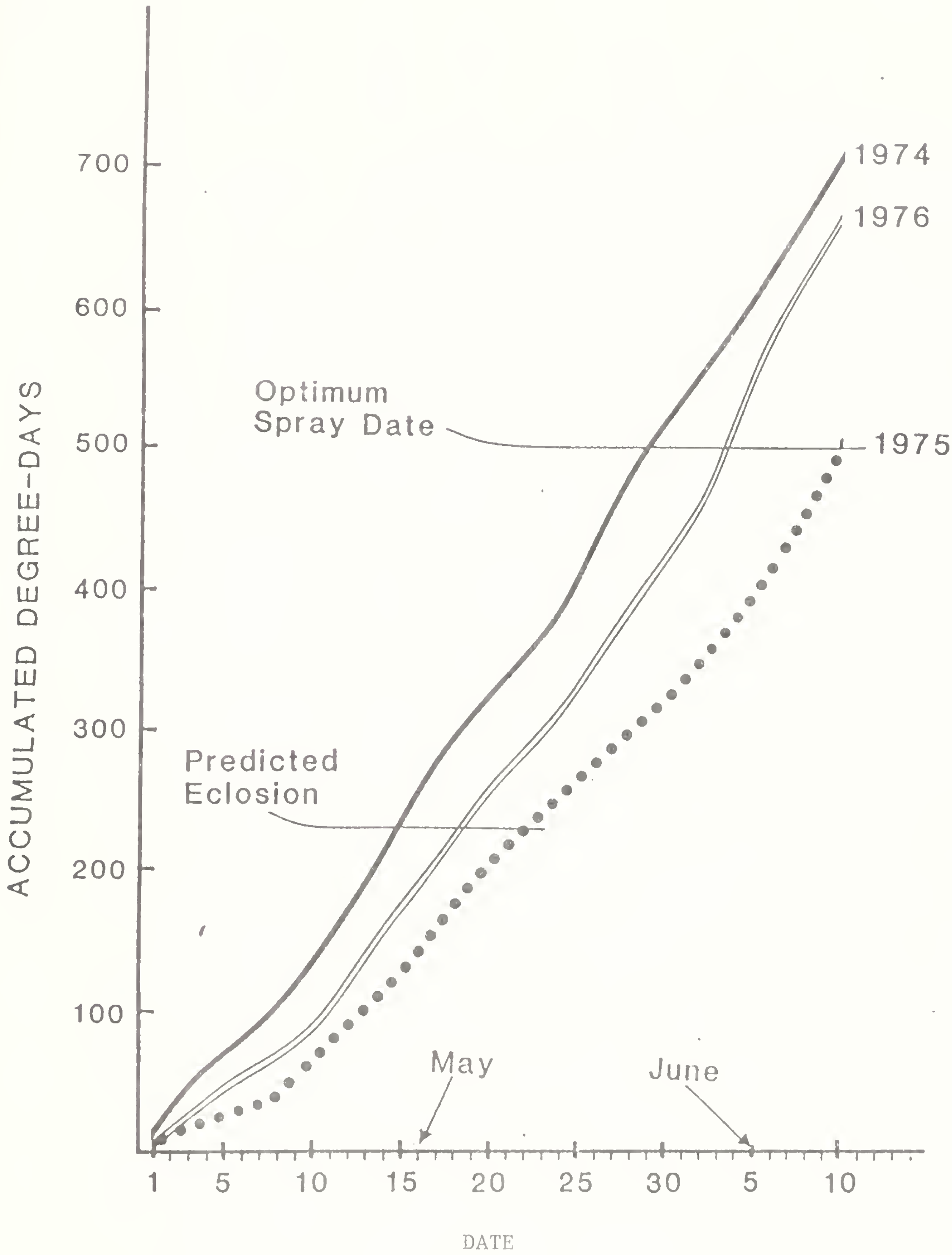
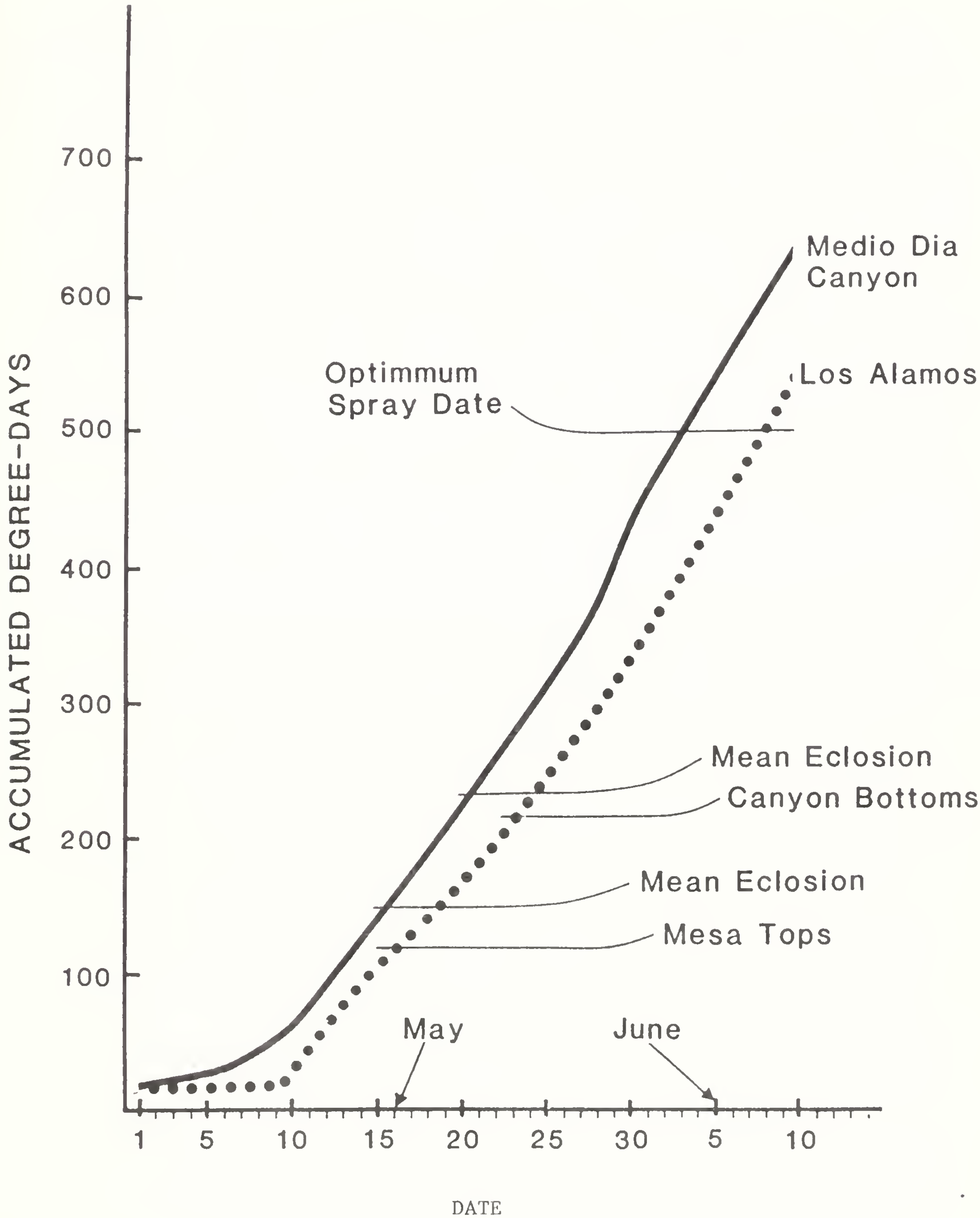


TABLE 1 -- Accumulated degree-days for Douglas-fir tussock moth eclosion and insecticide application 1974-78.

	Location and Year								
	Santa Fe			Los Alamos 1978		Medio Dia Canyon 1978		Mean ($\bar{x} \pm t_{.05}$ SE)	
	1974	1975	1976	Mesa tops	Canyon bottom	Mesa tops	Canyon bottom	Warm sites	Cool sites
Date of eclosion	5-14	5-21	5-18	5-15	5-22	5-15	5-19		
Accumulated Degree-days	233	220	222	120	215	165	232	143	224 $\pm$ 10
Date of spray	5-29	6-3	6-3	6-3/4	6-3/4	n/a	n/a		
Accumulated Degree-days	498	376	531	423-443	423-443	n/a	n/a	433	474 $\pm$ 79

Figure 2. Accumulated degree-days, eclosion date and optimal spray date, Medio Dia Canyon and Los Alamos, New Mexico, 1978



Eclosion appears to be governed by solar heating and photoperiod. In all tests eclosion occurred between May 14 and May 22. However, some effect from solar heating is evident in the Los Almos and Medio Dia data. Eclosion occurred 4 to 7 days sooner on the mesa tops than the canyon bottoms; degree-days averaged ca. 145 and ca. 225, respectively.

Using ca. 500 degree-days as the optimum for insecticide application, spray date was optimal on May 29 in 1974 and would have been optimal on June 9 in 1975 in Santa Fe. Optimal spray date from the canyon bottoms in Los Alamos would, also, have been June 9; however, substantial defoliation would have occurred on the mesa tops had the latter date been selected.

It should be emphasized that spraying a few days to a week after the optimal spray date will have minimal effect on total insect mortality. Some additional defoliation will obviously occur. Spraying before the optimal spray date, as in 1975, may fail to control the insect. The method presented provides the forest manager a way to determine the approximate timing for pre-spray sampling and suppression of the Douglas-fir tussock.

The data presented indicate that beginning May 1, eclosion occurs at ca. 220 degree-days, and optimal timing of insecticide occurs at ca. 500 degree-days. Accurate predications of the optimum treatment date will: (1) allow sufficient project planning time, (2) establish priority areas for spraying, and (3) insure better suppression of this insect.

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